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ULTRAVIOLET SOLAR-RADIATION INTENSITIES

RP816 in the August number of the Journal of Research describes ultraviolet filter transmission measurements, using a newly devised portable precision ultraviolet meter (J. Research NBS, 12, 231 (February 1934) RP647) and four glass filters, giving the spectral quality and total intensity in the band of ultraviolet solar radiation extending from about 2900 to 3500 A. At the high-altitude station (Flagstaff, Ariz.) data were obtained on solar ultraviolet intensities under various conditions: high and low humidity, large and small air masses, clear and smoky skies. The data obtained at sea-level stations (Washington, D. C., and San Juan, P. R.) are of interest in connection with the question of ultraviolet intensities in the Tropics, as compared with similar stations at higher latitudes.

Data are given on the amount of ultraviolet transmitted through light fog, on the amount reflected by the sky and by snow; also on the effect of altitude and latitude on the solar ultraviolet intensity at the earth's surface.

The observations show that while a light fog greatly reduced the intensity (when the sun appeared as a distinctly outlined white disk the intensity was reduced to one-tenth or less) the spectral quality is practically unchanged, owing to the relatively nonselective character of the transmission through water vapor. Similarly, the ultraviolet reflected from snow is extraordinarily high, owing to the fact that the ice crystals, within which the reflection occurs, are highly transparent to ultraviolet radiation.

The absorption of ultraviolet is caused by atmospheric pollution near the earth's surface and by ozone in the stratosphere. An increase of 40 to 50 percent in intensity in the band of wave lengths between 2900 and 3130 A is observed in rising 8 km (7,000 ft) above sea level. A much greater increase in intensity may be expected at elevations of 15 to 25 km (10 to 15 miles). However, such heights are not practicable for large-scale biological tests.

The measurements at the Flagstaff station show a greater atmospheric transparency (less ozone) in the afternoon than in the forenoon and a greater transparency in the autumn than in the spring. This is in agreement with the work of Dobson and others, using other methods of observation.

For the same solar altitude (that is for the same air mass traversed by the rays) the ultraviolet solar intensities in the tropics (at San Juan) were somewhat higher than at a midlatitude, sea-level station (Washington) that is free from local air pollution. This is in agreement with other observations showing that, in the tropics, for the same solar altitude the amount of atmospheric ozone is less, and consequently the ultraviolet intensities should be somewhat higher than in higher latitudes.

However, this small difference in intensity, for the same solar altitude, does not appear to be sufficient to produce marked differences in biological effects. If differences in biological effects that are ascribable exclusively to a difference in ultraviolet intensities are observable, they probably owe their origin to the fact that, for an interval of about 4 months (April 20 to August 20) at the noon hour, in the tropics, the sun shines through an air mass of m=1.00 to 1.01, as compared with an air mass of m=1.04 to 1.05 in midlatitude (Washington). Consequently, during this period the shortest—biologically most effective—wave lengths (at 2900 to 300 A) are very greatly increased in intensity. The average intensity of the whole spectral band (at 2900 to 3130 A, recognized as having a specific biologic action, at least in curing rickets) during the time when the sun shines through an air mass of m=1.00 to 1.01 is about 20 percent higher in the tropics than is ever attained in midlatitude.

Similarly, during the 5 winter months at midlatitude stations, the shortest, biologically most effective ultraviolet wave lengths are almost completely absorbed, and the intensity of the less-effective wave lengths is less than one-sixth the value that obtains in the tropics.

In addition to the greater intensity of the ultraviolet, there usually is also a greater number of hours of sunshine in the tropics during the winter months. Other factors to be considered are differences in air movement, temperature, humidity, and the amount of clothing worn, all of which factors have an effect in reducing the incidence of rickets, which is practically unknown in the tropics.

COLOR AND SPECTRAL TRANSMITTANCE OF VEGETABLE OILS

The market value of vegetable oils is determined largely by their color. For many years the commercial color grading of the oils has been based entirely on the Lovibond system of colored glass standards. Difficulties in the use of this system have arisen in practice, involving costly disputes between buyer and seller. These difficulties may not be ascribed solely to the method of color grading employed, but are largely inherent in the problem of the color measurement of the oils themselves.

As a rational physical basis for an analysis and discussion of the problem, an investigation of the spectral-transmissive properties of vegetable oils from different plant sources and varied geographical origin has been undertaken at the Bureau. The transmission of light at various wave lengths throughout the visible spectrum is basic data from which complete information on the color of the oils may be derived.

It is found that the major difficulty in the establishment of a satisfactory method for color grading lies in the fact that the oils contain several different coloring matters which may vary independently in concentration. This permits a wide two-way variation in color quality over the range of vegetable oils which is not fully encompassed by the color-grading method now employed. An improved grading method is desired, based on a suitable two-dimensional scale of color quality, which will more adequately cover the range of vegetable oil colors, reduce or avoid the use of many material color standards, and eliminate as nearly as possible the personal equation of the operator.

Efforts to meet these requirements are discussed in RP815 in the August number of the Journal of Research. Improvements in the present established procedure are suggested, along with some new methods which await further investigation.

FRACTIONATION OF THE ISOTOPES OF OXYGEN

The electrolytic fractionation factor for O^{16} and O^{18} defined as the ratio of O^{18}/O^{16} in the electrolyte to the same ratio in the oxygen gas evolved by electrolysis, has been found to be 1.05. An isotopic analysis of "equilibrium water" from a commercial electrolyzer indicates that about 11 ppm (parts per million) of the increase in density is a result of enrichment in heavy oxygen, and the value of 31 ppm previously reported is incorrect. For details concerning this correction RP820 in the August num-

ber of the Journal of Research should be consulted.

ANALYSIS OF TEXTILES CONTAINING FIBERS IN MIXTURE

A need for adequate methods for the quantitative analysis of textiles containing fibers in mixture has arisen as the result of the increased use of such mixtures, and the Bureau has undertaken to meet that need. The results of its work are given in RP821 in the Journal of Research for August.

The paper describes a method for the analysis of textiles containing two or more of the following fibers: Cellulose-acetate rayon (acetone-soluble type), silk, regenerated-cellulose rayon (including nitrocellulose, viscose, cuprammonium, and Lilienfeld types), cotton (including mercerized cotton), and wool.

The specimen to be analyzed is extracted with carbon tetrachloride to remove oils and fats, then treated with a starch and protein-hydrolyzing enzyme and washed with water to remove starch size, casein, glue, gelatin, and loading material, such as china clay.

Cellulose-acetate rayon is removed from a mixture of fibers by solution in acetone; silk by an aqueous solution of calcium thiocyanate of specific gravity 1.20; the regenerated-cellulose rayons by a thiocyanate solution of specific gravity 1.36; and the residue of cotton and wool treated with aluminum chloride and heat to remove cotton, or with potassium-hydroxide solution to remove wool.

The percentage of each of the fibers in the specimen analyzed by this method is accurate within 2 percent of the weight of the specimen.

ABSORPTION OF MOISTURE BY GELATIN-LATEX GAS-CELL FABRICS

The fabrics used in the construction of the gas-retaining cells in lighter-than-air craft are usually kept flexible by the introduction of materials known as plasticizers. These plasticizers often have the property of absorbing moisture from atmospheres of high relative humidity, and it is a customary procedure to use a protective coating on the fabric to reduce this tendency. To determine the effect of variations in amount, type, and distribution of the protective coating on the amount and rate of absorption of moisture, an investigation has been conducted at the Bureau on two lightweight fabrics which contained gelatin and latex, and which were plasticized with polyglycerol. As described in RP818 in the August number of the Journal of Research, each fabric was tested with coatings of different weights of paraffin on the outer side only; with a constant weight of paraffin on the inside and different amounts on the outside; with aluminum paint on the outside and paraffin on both sides; and with varnish containing aluminum dust applied to both sides.

It was found that the amount or distribution of paraffin did not affect the final values for the total amount of moisture absorbed when the relative humidity was below 94 percent. Slight increases in this total were found when varnish was present in the protective coating, as the varnish itself absorbed some moisture. At relative humidities above 94 percent mold growth occurred on the fabrics, some leaching of gelatin and polyglycerol took place, and the fabrics began to lose weight before the maximum possible amount of moisture was absorbed.

The rate of absorption of moisture was lowered by increasing the paraffin coating. The decrease in rate was greater when a given weight of paraffin was applied to both sides of the fabric than when it was used to increase the amount of coating on one side. The use of varnish containing aluminum dust gave higher rates of absorption than did the other coatings, though the varnish coating was heavier. The combination of paraffin and aluminum paint gave rates which were in some cases equivalent to those obtained with paraffin alone, and in others were slightly higher.

A comparison of the two fabrics used showed that the one with the smaller amount of gelatin and polyglycerol had a lower total absorption of moisture and gave smaller differences in rates of absorption for the variations in protective coating.

A consideration of the absorptive properties of the various constituents of the fabric, and of the permeability to moisture of the material surrounding the very hydroscopic gelatin layer, showed that combinations of these factors readily explained the moisture relations of the completed fabrics.

ISOLATION OF ETHYLCYCLOHEXANE FROM A MIDCONTINENT PETROLEUM

Ethylcyclohexane, never previously isolated from petroleum, has been sep-

arated in a nearly pure condition from a midcontinent petroleum. The work is part of an investigation in progress at the Bureau on the separation, identification, and determination of the constituents of petroleum—Research Project 6 of the American Petroleum Institute.

The isolated hydrocarbon is one of a general class of saturated monocyclic compounds called naphthenes, occurring in petroleum, which have the empirical formula C_nH_{2n}. Specifically, this is an octonaphthene, C_8H_{16}. Its identity has been established by comparison with a synthetic material of very high purity. The physical properties, including boiling point, freezing point, density, refractive index, critical solution temperature in aniline, and infrared-absorption spectrum of the isolated material have been compared with those of the synthetic hydrocarbon, with sufficient agreement to leave no doubt as to the identity of the petroleum constituent.

The compound was found in the fraction of the petroleum which distills normally between 131 and 133° C, and was separated from other constituents by physical means. Extended fractional distillation in highly efficient columns yielded a distillate concentrated in this component. Aromatic compounds had been previously completely removed by first extracting the major portion with liquid sulphur dioxide and then selectively absorbing residual amounts on silica gel. The purified distillate, though normally solidifying to a viscous glass, was separable by crystallization from solution in solvents of low viscosity, such as liquid propane and methane.

Final determination of the amount of ethylcyclohexane in this Oklahoma petroleum must await the completion of the analysis of the distillate boiling immediately below it, in which another naphthene is suspected. It is estimated, however, that the crude oil contains not more than 0.1 percent of the ethylcyclohexane. A more complete account of this work will be found in the August number of the Journal of Research (RP817).

HYDROTHERMAL SYNTHESIS OF KAOLINITE, DICKITE, BEIDELLITE, AND NONTRONITE

RP819 in the Journal of Research for August describes the synthesis of some of the clay minerals, undertaken at the Bureau to throw some light on the stability relations of these minerals and on their origin in nature. Coprecipitated Al_2O_3-SiO_2 gels and mixtures of different forms of Al_2O_3 and SiO_2 were heated with water in a steel bomb at temperatures from 310 to 390° C., which produced pressures from 97 to 260 atmospheres. Kaolinite, dickite, and beidelite were successfully synthesized under different conditions of temperature and corresponding pressure. Nontronite, the analogue of beidellite containing ferric oxide instead of aluminum oxide, was also synthesized. The products were identified by X-ray patterns. The data obtained substantiate the conclusion of geologists that kaolinite, the essential constituent of most clays, is the result of low temperature weathering action on feldspar and similar minerals, while dickite and nacrite are formed by the action of water under pressure at higher temperatures.

SUBSTITUTION OF AMERICAN KAOLINS FOR ENGLISH CHINA CLAYS

A paper on properties of American kaolins and their substitution for English china clays was published in the Journal of the American Ceramic Society for June 1935. The properties in which the English and most of the American clays studied were different, were found to be refractoriness, color, strength after heat treatment at less than cone 7, linear thermal expansion, and shrinkage and porosity after heat treatment at all temperatures. These differences were traced primarily to fundamental differences in the amount of fine-grained material present. The fact was brought out that the American kaolins contained less impurities than the English china clays. In order to obtain mixtures with properties similar to those of the English clays it was necessary to add fluxes such as feldspar and magnesium carbonate to the American clays. The paper contains data on chemical compositions, base exchange capacities, colloidal contents, transverse strengths, shrinkages, and porosities and thermal expansions of clays tested.

GASES EVOLVED FROM METALS ON HEATING

Determination of the small amounts of the gaseous elements, oxygen, nitrogen, and hydrogen which exist in a variety of forms and combinations in steel and many metals, has received a great deal of attention at the Bureau for several years past. This pioneer

work has been supplemented by extended studies in numerous other laboratories.

For iron and steel samples the Bureau uses the vacuum-fusion method for determining oxygen, nitrogen, and hydrogen, although this method necessitates the use of rather elaborate equipment in the operation of which very considerable skill is required. Hitherto, these analyses have been time-consuming to the extent that a full day's work was required for each sample. However, recent improvements in the apparatus and technique have more than doubled the speed with which determinations can be made. Determinations on as many as 3 samples can now be made in 1 day, apparently without any sacrifice of precision or reliability.

SERVICE LIFE OF STEEL FORGING

A study of the properties of a metal after practical service use is usually very instructive, particularly if the service conditions are unusual or severe. An examination was completed a short time ago in the Bureau's metallurgical division of a hollow cylindrical steel forging used as a reaction chamber for the high-pressure synthesis of ammonia. After approximately 8 years' use the cylinder was scrapped as a precautionary measure, and the examination was made in order to determine to what extent the steel had deteriorated in this service, namely, contact with hydrogen and nitrogen under a pressure of several hundred atmospheres and at a temperature of approximately 150° C.

The tensile properties of the steel (2.54 percent chromium, 0.24 percent vanadium) close to the inner wall of the chamber did not differ from those of the steel in the middle of the section (2¼ inch), and were identical with the results reported for the forging when it was made. The only suggestion of deterioration was a decarburized layer, 0.01 to 0.03 inch thick, on the inner wall of the chamber which, however, was too shallow to have any significant weakening effect on the strength of the cylinder. Other than this, there was no evidence of deterioration in the steel from the service to which it had been subjected.

DO METALS "CRYSTALLIZE" UNDER VIBRATION?

In published accounts of a recent endurance flight of an airplane, widespread publicity was given to the belief that metals may fail as a result of crystallization caused by vibration in service. This erroneous belief probably originated in an incorrect conclusion drawn from the typical appearance of the fractured surfaces of metals that failed after having been subjected to repeated cycles of service stresses.

It has been known for a long time that all metals in the solid state are aggregates of crystalline grains, generally of microscopic size. It is also known that the original crystalline structure cannot be altered by purely mechanical forces which do not permanently alter the outward form of the metal piece.

When a metal breaks from a single application of a force, the fracture takes place along natural cleavage planes through the crystal grains and the fracture exhibits a characteristic crystalline appearance. In ductile metals, fracture does not take place until considerable deformation has occurred.

However, when metals are subjected to repeated applications of force, fracture can occur without deformation, even in the most ductile metals, if the range or amplitude of the force exceeds a limiting value. For steels this value is generally about 50 percent of its strength under steady loads, but may be as low as 20 percent or as high as 60 percent. This value is known as the endurance or "fatigue" limit. The fracture originates at a point where the stress is the maximum, or in some localized weakness. The crack itself, once started, is a localized weakness and grows with repeated stress application, generally perpendicularly to the direction of the applied forces.

As the advancing crack cuts off more and more of the sound metal, the load is carried by a progressively decreasing area, and finally sudden and complete rupture of the members occurs. The combination of the sudden break with the formation of a fracture which one is accustomed to find in very brittle materials is naturally disconcerting.

To one not familiar with the inherently crystalline structure of metals and the nature of the process of fracturing, it is perhaps only natural to conclude, from the observation of such a fracture that a portion of the metal had "crystallized" and therefore becomes brittle, and failed unex-

pectedly. Such a conclusion is nevertheless contrary to the known facts. A short "brittle" fracture in a metal is just as normal and characteristic as the more familiar "ductile" type.

LIGHT-WEIGHT CONSTRUCTION

The Edgar Marburg Lecture for 1935 was delivered by Dr. L. B. Tuckerman of the Bureau's staff at the meeting of the American Society for Testing Materials in Detroit on June 26. While Dr. Tuckerman pointed out that all fields of science and technology have contributed to the development of the modern airplane, his paper was limited to the relations between the mechanical properties of material and the design of struts, beams, girders, stressed skin, etc., and the craft as a whole to produce lightweight aircraft.

The major structural problem in aircraft is lightweight construction, and its significance was emphasized by a comparison of power-driven vehicles—locomotive, steamship, automobile, airplane, and airship—on the basis of their structural density, their structural fineness ratio, and the loads to which they were subjected. It was pointed out that aircraft demand structures not merely lighter but of an entirely different order of lightness than had been necessary before. Success in meeting this demand has come from a combination of empirical design with theoretical investigations, and materials and structural tests of a volume unprecedented in the history of any comparable structural field.

Theoretical and experimental investigations all show that to secure light-weight construction the material must be spread out as far as possible from the axis of the structure or its structural elements. Typical light-weight construction is therefore thin-walled construction, i. e., thin webs, thin flanges, thin-walled tubes, thin sheet surfaces, etc. The limit of the spreading is set by local instabilities: wrinkling, twisting, crumpling, or other types of collapse of the thin material. The problem is to secure the best possible balance between plastic yielding, depending upon the strength-density ratio of the material, and major or local instabilities dependent upon its modulus-density ratio, and finally the transitions between them dependent upon an accurate knowledge of its stress-strain curve. These conclusions were illustrated by examples of simple structural members used in aircraft.

In the light of these conclusions the significant properties, density, strength-density ratio, and modulus-density ratio of selected materials were compared. The comparison showed that from these purely structural considerations there is little choice between the three types of construction now in use, wood, light aluminum alloys, and high-strength alloy steels. The choice between them must be based on other considerations, ease of fabrication, resistance to deterioration by weathering, etc., and finally upon knowledge of the designs which will utilize best the possibilities of the material.

Improvement in the quality of structural metals, which increases the ease of fabrication, and improvements in the technique of fabrication and joining of metal by such processes as riveting, crimping, soldering, brazing, and welding will make possible improved designs which are now impossible to fabricate.

With the best designs so far produced it is possible to utilize fully the strength of materials already available only in relatively small parts of the structure. The modulus-density ratio is still the limiting property of the material and this ratio is practically unaltered by any treatment which can be given a material. Consequently no radical improvement in light-weight construction is at present to be expected from still further increasing the strength of the materials.

However, as our fund of knowledge increases, designs will be worked out that will make better use of materials now available, so as to utilize their strength more fully. It is along this line that great improvements are to be expected. Systematic tests on typical structural elements, covering ranges of materials, over-all dimensions, wall thicknesses, and types of loading should be made. Tests such as these promise material improvements in light-weight construction. While tests of this kind are being carried out in numerous laboratories, many more are needed if progress in light-weight construction is to be maintained.

In conclusion, Doctor Tuckerman pointed out that the principles, materials, and technique of light-weight construction, developed chiefly in connection with aircraft, are being increasingly used in other fields of construction, notably in the building of light-weight railroad trains.

NEW AND REVISED PUBLICATIONS ISSUED DURING JULY 1935

Journal of Research [1]

Journal of Research of the National Bureau of Standards, vol. 15, no. 1, July 1935 (RP 804 to 814, inclusive). Price 25 cents. Obtainable by subscription.

Research Papers [1]

[Reprints from the April and May 1935 numbers of the Journal of Research]

RP780. Recent studies of the ionosphere. Samuel S. Kirby and Elbert B. Judson. Price 5 cents.

RP783. Arc spectrum of copper in the infrared. C. C. Kiess. Price 5 cents.

RP785. A filter for obtaining light at wave length 560 mμ. Kasson S. Gibson. Price 5 cents.

RP786. Refractive index of rubber. Archibald T. McPherson and Arthur D. Cummings. Price 5 cents.

RP787. Amino-nitrogen contents of wool and collagen. Joseph R. Kanagy and Milton Harris. Price 5 cents.

RP789. Gold-cobalt resistance alloys. James L. Thomas. Price 5 cents.

RP790. A method for finding the roots of the equation $f(x)=0$ where f is analytic. Charles L. Critchfield and John Beek, Jr. Price, 5 cents.

RP791. Heats of reaction of the system: rubber-sulphur. Archibald T. McPherson and Norman Bekkedahl. Price, 5 cents.

RP792. Thermal behavior of the kaolin minerals. Herbert Insley and Raymond H. Ewell. Price, 5 cents.

RP793. Multiplets and terms in the first two spectra of columbium. William F. Meggers and Bourdon F. Scribner. Price, 5 cents.

Simplified Practice Recommendations [1]

R17–35. Forged tools. Price, 5 cents.

Technical News Bulletin [1]

Technical News Bulletin 219, July 1935. Price, 5 cents. Obtainable by subscription.

[1] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription for Technical News Bulletin, 50 cents per year; Journal of Research, $2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and the Republic of Panama); other countries 70 cents and $3.25, respectively.

LETTER CIRCULARS

Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards and are sent only on request to persons having a definite need for the information. The number of copies available is limited. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or to send copies automatically as issued.

LC444. Hardened copper. (Replaces LC61.)

LC445. Painting steam and hot-water radiators. (Replaces LC263.)

REPORTS OF NATIONAL HYDRAULIC LABORATORY

[Mimeographed. Sent in answer to specific requests addressed to the National Bureau of Standards.]

Current Hydraulic Laboratory Research in the United States. Report no. III–2 (July 1, 1935).

OUTSIDE PUBLICATIONS [2]

Values of discharge coefficients of square-edged orifices. Howard S. Bean. Am. Gas Assn. Monthly (420 Lexington Ave., New York, N. Y.) **17**, 259 (July 1935).

Computing volumetric components of fluid mixtures. S. H. Ingberg. Chem. & Met. Eng. (330 W. 42d St., New York, N. Y.) **42**, 317 (June 1935).

Cooperative Fuel Research Committee report on 1934 detonation road tests discussed: Available data analyzed further. Donald B. Brooks. Soc. Automotive Engrs. J. (29 W. 39th St., New York, N. Y.) **36**, 215 (June 1935).

Fading of dyeings. William D. Appel. Am. Dyestuff Reporter (440 Fourth Ave., New York, N. Y.) **24**, 306 (June 3, 1935).

Selective adsorption from soap solutions. Harvey A. Neville and Milton Harris. Am. Dyestuff Reporter **24**, 312 (June 3, 1935).

Reflection measurements on pulp and paper. Richard S. Hunter. Paper Trade J. (10 E. 39th St., New York, N. Y.) **100**, 37 (June 27, 1935).

[2] These publications are not obtainable from the Government. Unless otherwise stated requests should be sent direct to the publishers.

Continuous-flow corrosion tests of steel pipe. Henry S. Rawdon and L. J. Waldron. Reprint 28, Am. Soc. Testing Materials (260 S. Broad St., Philadelphia, Pa.) (June 1935).

Atmospheric exposure tests of nonferrous screen wire cloth. G. W. Quick. Appendix to Report Comm. D–14, Am. Soc. Testing Materials (June 1935).

A discussion of thermal spalling of fire-clay brick with relation to Young's modulus of elasticity, thermal expansion and strength. R. A. Heindl. Tech. Bul. 58, Am. Refractories Institute (c/o S. M. Phelps, Refractories Fellowship, Mellon Institute, Pittsburgh, Pa) (May 1935).

The relation of freezing and thawing resistance to physical properties of clay and shale building brick. J. W. McBurney. Preprint 43, Trans. Am. Soc. Testing Materials (June 1935).

Comparison of natural weathering with laboratory tests of clay brick. D. E. Parsons. Preprint 43, Trans. Am. Soc. Testing Materials (June 1935).

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